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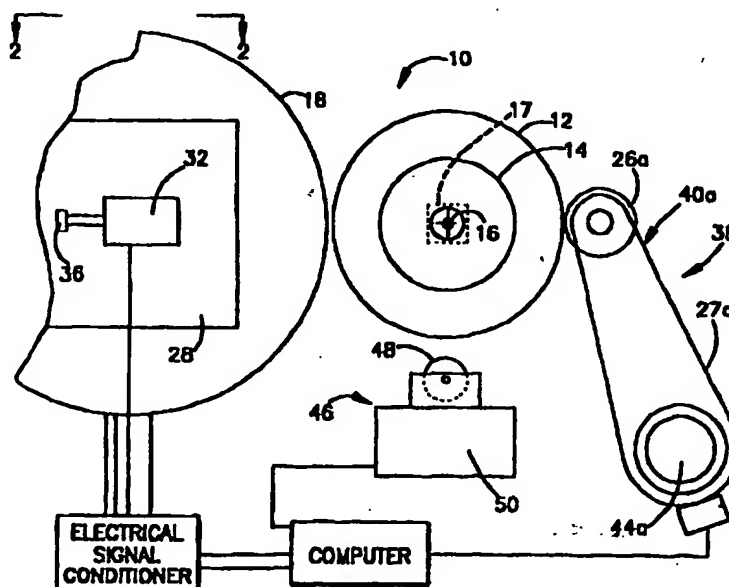
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(54) Title: METHOD OF ENHANCING THE MEASUREMENT ACCURACY OF A TIRE UNIFORMITY MACHINE



(57) Abstract

A method for enhancing the measurement accuracy of a tire uniformity machine by combining signals generated by supplementary load cells with signals generated by corresponding measuring load cells to vibration signals generated by the tire uniformity machine.

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METHOD OF ENHANCING THE MEASUREMENT
ACCURACY OF A TIRE UNIFORMITY MACHINE

FIELD OF THE INVENTION

10 This invention relates to the field of enhancing
the measurement accuracy of a machine, and more
particularly to a method of enhancing the measurement
accuracy of a tire uniformity machine by combining
differential signals generated by supplementary load
cells with signals generated by measuring load cells
15 to cancel signals generated by the vibration of the
tire uniformity machine.

BACKGROUND OF THE INVENTION

20 In the art of manufacturing pneumatic tires,
rubber flow in the tire mold or minor differences in
the dimensions of the belts, beads, liners, treads,
plies of rubberized cords, etc., sometimes cause non-
uniformities in the final tire. Non-uniformities of
a sufficient amplitude will cause force variations on
a surface, such as a road, against which the tires
25 roll which produce vibrational and acoustical
disturbances in the vehicle upon which the tires are
mounted. Regardless of the cause of the force
variations, when such variations exceed an acceptable
maximum level, the ride of a vehicle utilizing such
30 tires will be adversely affected.

5 Methods have been developed in the past to
correct for excessive force variations by removing
rubber from the shoulders and/or the central region
of the tire tread by means such as grinding. These
correction methods are commonly performed with a tire
10 uniformity machine, which includes an assembly for
rotating a test tire against the surface of a freely
rotating load wheel. In this testing arrangement,
the load wheel is moved in a manner dependent on the
forces exerted by the rotating tire and those forces
15 are measured by appropriately placed measuring
devices, e.g., load cells. When a tire being tested
yields less than acceptable results, shoulder and
center rib grinders are used to remove a small amount
of the tire tread at precisely the location of non-
20 uniformities detected by the measuring devices. As
the tire is rotated, it is measured and ground
simultaneously. In a sophisticated tire uniformity
machine (TUM), such as a Model No. D70LTW available
from the Akron Standard Co. of Akron Ohio, the force
25 measurements are interpreted by a computer and rubber
is removed from the tire tread using grinders
controlled by the computer. Examples of tire
uniformity machines utilizing these methods are
disclosed in U.S. Patent Nos. 3,739,533, 3,946,527,
30 4,914,869, and 5,263,284.

5 Any vibration that is generated by the tire
uniformity machine is detected by its force variation
measuring elements, i.e., the load cells. Small
quantities of vibration caused by extraneous sources
are acceptable because electronic filters are used to
10 remove this extraneous noise. But when the motor
bearings wear out, or the grind wheels are defective
or improperly installed, or noise and vibration from
machines external to the tire uniformity machine are
present, excessive vibration will occur. Detection
15 of this excessive vibration by the force measuring
elements, i.e., the load cells, can cause inaccurate
measurement of the force variations of the tires
being measured on the tire uniformity machine. This
in turn can result in the tire tread being ground at
20 the wrong locations to eliminate excessive force
variations of the tires, resulting in longer grind
times, fewer tires processed, and more scrap tires.

Currently, the prior art method of detecting
excessive vibration is to use an external vibration
25 analyzer with a movable accelerometer, which a
technician manually locates on different points of
the tire uniformity machine. Problems with this
technique are that the equipment is costly, it takes
several hours to complete the vibration analysis, and
30 the resulting downtime of the tire uniformity machine
is expensive. Also, since defects in the machine are

5 computer. A plurality of differential input sections
convert differential voltage signals from the
supplementary load cells into differential signals
that can be inputted into the computer. A signal
summing section is provided to sum the force
10 measurement signals and the differential signals and
to output the difference between the measurement
signals and the differential signals to the computer.

Also in accordance with the invention, a method
of enhancing the measurement accuracy of a tire
15 uniformity machine comprising the following steps.
The forces generated by the vibration of the tire
uniformity machine are monitored with primary load
cells supporting a wheel spindle of the tire
uniformity machine with a freely rotating load wheel
20 mounted thereon and force measurement voltage signals
are generated in response thereto. The forces
generated by the vibration of the tire uniformity
machine are monitored with supplementary load cells
mounted to the tire uniformity machine and
25 differential voltage signals are generated in
response thereto. The force measurement voltage
signals generated by the primary load cells are
converted into analog voltage measurement signals.
The differential output voltage signals are reversed
30 and converted into analog differential signals. The

5 analog voltage measurement signals and the analog
differential voltage signals are summed and summed
analog voltage signals equal to their difference are
outputted to the computer to substantially cancel the
effect of vibrational forces generated by the tire
10 uniformity machine.

It is an object of the present invention to
provide a method for measuring the quantity of
extraneous vibration in a tire uniformity machine.

15 A further object is to obviate the problems and
limitations of the prior art methods. Other objects
of this invention will be apparent from the following
description and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

20 The structure, operation, and advantages of the
presently preferred embodiment of the invention will
become further apparent upon consideration of the
following description taken in conjunction with the
accompanying drawings, wherein:

25 Fig. 1 is a schematic illustration of a plan
view of a tire uniformity machine in accordance with
the invention with a tire mounted thereon;

30 Fig. 2 is a schematic illustration of a side
view through line 2-2 of Fig. 1, showing a load wheel
mounted between two primary load cells which generate
output signals in response to the force variations of

5 a tire, two supplementary load cells mounted to the frame of the tire uniformity machine, and electrical circuitry for detecting and canceling extraneous vibrations picked up by the tire uniformity machine;

10 Fig. 3 is a schematic illustration of the electrical circuitry interconnecting one of the primary load cells to a corresponding supplementary load cell; and Figs. 4A and 4B, collectively Fig. 4, is flow diagram of the process of the present invention.

15 DETAILED DESCRIPTION OF THE INVENTION

Referring to Figs. 1 and 2, there is illustrated a tire uniformity machine (TUM) 10 in accordance with the invention adapted for mounting a tire 12. Tire 12 is typically a pneumatic tire having a circumferential tire tread with top and bottom shoulder regions and a central region between the top and bottom shoulder regions. The tire 12 can be mounted on a rim 14 secured to a tire spindle 16 and inflated to a desired pressure. A variable speed motor 17, shown with phantom lines, rotates the tire spindle 16 and rim 14. The tire 12 can be placed under load by a load wheel 18, which is rotatably supported on a fixed spindle 20 extending through the load wheel and suspended from primary load cells 22, 24 at either end. The primary load cells 22, 24,

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25
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5 in turn, are mounted to the frame supports 26,28,
respectively, of the tire uniformity machine. Each
of the primary load cells 22,24 includes a lateral
load cell section conventionally used to measure the
lateral force exerted by the tire 12 against load
10 wheel 18 in a direction parallel to the axis of
rotation extending about which the load wheel
rotates. The primary load cells 22,24 also include a
radial load cell section conventionally used to
measure the radial force at the point of intersection
15 of the tire 12 and the load wheel 18 exerted by the
tire 12 against the load wheel 18 and through spindle
20 about which the load wheel rotates.

An important aspect of the present invention
relates to the provision of supplementary load cells
20 30,32 mounted in close proximity to the primary load
cells 22,24, such as on the frame supports 26,28,
respectively, as shown. Each supplementary load cell
30,32 has a fixed mass, such as weight 34,36,
respectively, attached thereto to simulate the fixed
25 mass attached to each of the primary load cells
22,24, respectively. While the supplementary load
cells 30,32 are shown mounted to frame supports 26,28
in one location, it is also within the terms of the
invention to mount them at other locations on the TUM

5 10, as long as they are in close proximity to and oriented in the same direction as primary load cells 22,24.

During the testing of a tire 12 for non-uniformities, the load wheel 18 is pressed against
10 the tire to load the inflated tire with a specified force (for example, 600 to 1900 lb) to simulate road conditions. The spindle 20 is mounted to bearing blocks (not shown) and is moved by conventional means, such as an electric motor (not shown)
15 operating through a ball-and-screw connection, to move the load wheel 18 into and out of engagement with the tire 12.

A shoulder grinding assembly 38 is located substantially 180° with respect to tire 12 from load
20 wheel 18. The shoulder grinding assembly 38 includes substantially identical top and bottom shoulder grinders 40a and 40b (only top shoulder grinder 40a is illustrated and described), which include grinding wheels that are powered by motors and are
25 independently moved into and out of engagement with the shoulder regions of tire 12. As shown, the top shoulder grinder 40a has a grinding wheel 42a powered by a motor 44a and can be moved into and out of engagement with the shoulder portions of tire 12 by
30 any conventional means, such as an hydraulic servo

5 device (not shown). A center grinder assembly 46 is
located adjacent wheel 12 approximately 90° counter-
clockwise about tire 12 from load wheel 18. The
center grinder assembly 46 has a grinding wheel 48
that is powered by a motor 50 and is moved into and
10 out of engagement with the central region of the
tread of tire 12 by conventional means, such as with
an hydraulic servo device (not shown).

Voltage signals, proportional to the amplitude
of the radial and/or lateral forces, are generated by
15 primary load cells 22,24 and inputted through lines
52 and 54, respectively, into an electric signal
conditioner 56. The electric signal conditioner 56
includes substantially identical signal conversion
sections 58 and 60 which convert the force
20 measurement voltage signals generated by primary load
cells 22,24, respectively, into signals that are
conditioned so that they can be inputted to and
stored in a computer 62. The signal conversion
sections 58 and 60, as shown in Fig. 3, each includes
25 at least one amplifier 64 connected by lines 52,54 to
primary load cells 22, 24, respectively. The
amplified output signal from the amplifier 64 is
directed through line 66 into an anti-aliasing filter
68 to cut off the high frequency outputs, i.e.
30 greater than approximately 45 Hertz, from primary

5 load cells 22,24 so that the high frequency content
 contained in the amplified load cell signal does not
 cause aliasing in the analog to digital conversion.

 The electric signal conditioner 60 also includes a
 low pass filter 70 connected in series to anti-
10 aliasing filter 68 through line 72. The low pass
 filter 70 attenuates frequencies greater than 16
 hertz, from the amplified output signal of amplifier
 64 so that the signal bandwidth is limited to
 frequencies generated by the tire and load wheel.

15 The output signal from low pass filter 62 is directed
 through lines 74,76 into a signal summing sections
 78,80, respectively, as discussed below.

 The present invention is directed to the
 measurement and elimination of deviations from the
20 prescribed specifications of the TUM 10, i.e.,
 operating under conditions without extraneous
 vibrations, caused primarily by extraneous vibrations
 generated by or induced in machine 10. The
 extraneous vibrations are caused by rotating
25 components such as a motor-driven tire spindle 16,
 the tire grinding assemblies 38, and the center
 grinding assembly 46, the motor bearings wearing out,
 the grind wheels being defective or improperly
 installed, and/or noise and vibration from machines
30 external to the tire uniformity machine 10. The

5 primary sensors for many of the required measurements
used in operating the TUM 10 are primary load cells
22,24 which are normally in the electrical
differential mode. This fact, combined with the
inherent low impedance of primary load cells 22,24,
10 usually provides an adequate quality signal output
for the TUM 10. The primary load cells 22,24,
however, cannot discriminate between the signal
components generated by the force measurement of the
tire and a vibration or force component generated by
15 an extraneous vibration generated or picked up by the
TUM 10.

To overcome the problem of the readings of the
primary load cells 22,24, being corrupted by
extraneous vibrations, supplementary load cells
20 30,32, with substantially identical characteristics
to the primary load cells 22,24 are mounted to the
TUM 10 so as to be oriented in the same direction and
in very close proximity to the primary measuring load
cells 22,24, respectively. The supplementary load
25 cells 30,32 have a fixed mass, such as weight 34, 36,
respectively, attached thereto. The output voltage
signals from the supplementary load cells 30, 32 are
directed through pairs of electrical lines 80 and 81
into substantially identical differential input
30 sections 84,86, respectfully. Since differential

5 input sections 84,86 are substantially identical,
only differential input sections 86 is shown and
described. Referring to Fig. 3, the pair of
electrical lines 82 are reversed in differential
input section 86 and are inputted into a gain
10 adjustment amplifier 88. The differential voltage
signal being output from gain adjustment amplifier 88
is then directed into a line 90 and into a phase
adjustment amplifier 92. The voltage output signal
from phase adjustment amplifier 92 is then outputted
15 through line 94 into signal summing section 78. The
voltage signals through electrical lines 76 and 94
are directed through resistors 96 and 98,
respectively, and then combined into line 100 and
inputted into a summing amplifier 102. The summing
20 amplifier 102 subtracts the voltage signals from
lines 94 and 76 and the resulting amplified signal
from summing amplifier 102 is then outputted from
signal summing section 80 through line 106 into
computer 62. At the same time, the resulting
25 amplified signal outputted from signal summing
section 78 through line 106 is directed into computer
62.

Each supplementary load cell 30,32 and
corresponding primary measuring load cell 22,24
30 measure virtually the same noise and vibration

5 components when the TUM 10 is running with no load on
the load wheel 18. Since both the primary load cells
22,24 and their corresponding supplementary load
cells 30,32 are operating in the differential mode,
the pair of signal wires 81,82 from the supplementary
10 load cells can be reversed, as shown in Fig. 3,
without any adverse electrical effects. Using this
configuration, a positive vibration in the TUM 10
will generate both a positive signal output from the
primary measuring load cells 22,24 and a negative
15 signal output from the supplementary load cells
30,32. Assuming that the corresponding primary and
supplementary load cells 22 and 30, 24 and 32 and the
masses attached to each of them are identical, the
two output voltage signals being outputted through
20 lines 74 and 76 from signal conversion sections 58,60
and the two differential output voltage signals being
outputted through lines 95,94 from differential input
sections 84,86 will theoretically cancel each other
in the signal summing sections 78,80. However, a
25 very small residual error might still be present
because of the phase shift induced by the slightly
different locations of the corresponding primary and
supplementary load cells. The gain of amplifier 88
can be adjusted to account for the difference between
30 the mass 34,36 of supplementary load cells 30,32 and

5 the mass associated with each of the primary load
cells 22 and 24. The amplifier 92 provides a phase
angle adjustment which can be adjusted to correct for
the difference in location of the supplementary load
cells 30,32 with respect to the corresponding primary
10 load cells 22 and 24. That is, the machine 10 can be
calibrated with the rotating portions, such as the
motors and grinders turned off. First, an external
vibration is induced in machine 10 by a conventional
vibration generating device, such as a Model No. 2706
15 power amplifier and Model No. 4809 shaker from Beuel
& Kjaer of Denmark. The gain and phase of the
voltage output signals from the supplementary load
cells are adjusted with amplifiers 88 and 92 in
sections 84 and 86 so that there is a minimum
20 difference between the output voltage signals being
outputted by the summing sections 78 and 80 as
calculated by computer 62. This calibration
effectively cancels the vibration signals induced in
the TUM 10 that are picked up by both the primary and
25 supplementary load cells.

Referring to Fig. 4, there is illustrated a flow
diagram of the present invention. When a TUM 10,
which incorporates the electric signal conditioner 56
of the present invention is running without force
30 applied by the load wheel 18, the voltage signals

5 inputted through lines 104 and 106 into the computer
62 will be close to zero. As a load is applied by
load wheel 18 against tire 12, the measuring load
cells 22,24 will respond to the additional load plus
the vibration components produced by the rotating
10 components and any extraneous vibrations. The
supplementary load cells 30,32 will see only the
vibration components produced by the rotating
components and any extraneous vibrations. When the
voltage signals from the corresponding primary and
15 supplementary load cells 22,30 and 24,32 are
subtracted in summing sections 78,80, the vibrational
components measured by the primary load cells will be
canceled out. The remaining signal components,
generated by the primary load cells 22,24 will, for
20 the most part, result from the load forces of the
tire against the load wheel 18. That is, the two
analog signals being outputted from signal summing
sections 78,80 correspond to the monitored radial
and/or lateral forces with very low background noise
25 generated by the tire 12 loaded against the load
wheel 18 during a predetermined period of time.

 The computer 62 independently samples the analog
signals being inputted from the summing sections
78,80 for a predetermined time and converts the
30 analog signals to digital signals. Next, computer 62

5 converts the digital signals to a frequency domain
signal representation using a Conventional Fast
Fourier Transform (FFT) program for each of the
primary load cell signals less the supplementary load
cells being monitored. By calculating a FFT for each
10 primary load cell signal independently, the phase
shift for each primary load cell can be calculated
and a correction table generated for each frequency
present in the spectrum. Also, by storing the
results of the FFT's for each primary load cell
15 22,24, signals can be acquired periodically while
running without a load on the tire and new FFT's can
be calculated and compared with the original FFT's.
Comparing the frequency spectrum and the amplitudes
of each rotating component of TUM 10 would enable an
20 operator to discover the malfunction of some part of
the rotating components. The malfunction could
generate an alarm signal.

 The computer 62 then operates on the frequency
domain signal representation to calculate a power
25 spectrum, as discussed in the previously discussed
U.S. Patent Application entitled Method of Machine
Vibration Analysis For The Tire Uniformity Machine,
of discrete frequency components in hertz versus the
amplitude or magnitude of the discrete frequency
30 components in pounds. Selected frequency components

5 are then compared with selected groupings of
frequencies representing critical frequencies of
different moving parts of the tire uniformity machine
10. An acceptable amplitude for the selected groups
of frequencies, representing critical frequencies of
10 the moving parts operating as designed, is inputted
into the computer. If the amplitude of the different
groups of frequencies generated from the voltage
signals outputted by the summing sections 78 and 80
is greater than the acceptable amplitudes for
15 selected groups of frequencies corresponding to the
various moving parts of the tire uniformity machine,
an alarm signal is output by the computer. The alarm
signal indicates that a rotating portion of the tire
uniformity machine 10 is defective. The alarm signal
20 could be inputted into a display monitor and/or used
to activate an alarm device such as a light or
audible alarm, i.e., a bell or buzzer, to alert a
machine operator that the tire uniformity machine 10
is vibrating at a level beyond an acceptable limit.
25 The moving component of the tire uniformity machine
10 or external vibration source which is causing the
unwanted vibration, can be isolated as generally
described in the application entitled Method of
Machine Vibration Analysis For The Tire Uniformity
30 Machine.

5 Computer 62 is conventionally programmed to
determine the conicity, lateral force values, radial
run-out, and radial force values of the tire 12, and
to control the corrective grinding action to take, as
discussed in U.S. Patent Application Serial No.
10 08/534,809, entitled METHOD OF CORRECTING CONICITY,
RADIAL RUN OUT, AND FORCE VARIATIONS IN A PNEUMATIC
TIRE, assigned to The Goodyear Tire & Rubber Co., the
assignee of the present invention, is connected to
the shoulder grinding assembly 24 and to the center
15 grinder assembly 26 to position these grinding
assemblies, as required.

It is also within the terms of the present
invention to scale the supplementary load cell
capacity and the mass of the reference weight
20 attached to the supplementary load cells, and thereby
reduce the mass and physical size of the referenced
weights 34 and 36 for easier installation.

While the invention is described in connection
with a tire uniformity machine, it is within the
25 scope of the invention to eliminate the extraneous
vibrations induced in other types of machines
incorporating load cells.

It is apparent that there has been provided in
accordance with this invention apparatus and methods
30 for enhancing the measurement accuracy of a tire

5 uniformity machine by subtracting differential
signals generated by supplementary load cells with
signals generated by primary measuring load cells to
cancel the portion of the signals of the primary
measuring load cells which corresponds to the
10 vibration of the tire uniformity machine so as to
satisfy the objects, means and advantages set forth
hereinbefore.

15 While the invention has been described in
combination with embodiments thereof, it is evident
that many alternatives, modifications, and variations
will be apparent to those skilled in the art in light
of the foregoing teachings. Accordingly, the
invention is intended to embrace all such
alternatives, modifications and variations as fall
20 within the scope of the appended claims.

5 WE CLAIM:

1. An apparatus for enhancing the measurement accuracy of a tire uniformity machine, comprising:

10 a plurality of primary load cells supporting a load wheel spindle with a freely rotating load wheel mounted on said spindle;

a plurality of supplementary load cells each mounted to said tire uniformity machine in close proximity to a corresponding one of said plurality of primary load cells, each of said plurality of
15 supplementary load cells having a fixed mass attached thereto;

an electric signal conditioner including:

20 a plurality of signal conversion sections which convert force measurement voltage signals generated by said plurality of primary load cells into force measurement signals that can be inputted into a computer;

25 a plurality of differential input sections to convert differential voltage signals from said plurality of supplementary load cells into differential signals that can be inputted into said computer; and

30 a signal summing section to sum said force measurement signals and said differential signals and to output the difference between

5 said measurement signals and said differential
 signals to said computer.

10 2. The apparatus of claim 1 wherein said
 plurality of differential input sections are each
 connected to one of said plurality of supplementary
 load cells through a pair of lines that are reversed
 and connected to a amplifier, said plurality of
 differential input sections each having a phase
 adjustment amplifier and a gain adjustment amplifier
 connected in series to each other.

15 3. The apparatus of claim 2 wherein said
 plurality of signal conversion sections each includes
 at least one amplifier connected by lines to one of
 said plurality of primary load cells.

20 4. The apparatus of claim 3 wherein said
 plurality of signal conversion sections each includes
 an anti-aliasing filter connected in series to the
 output of said at least one amplifier.

25 5. The apparatus of claim 4 wherein said
 plurality of signal conversion sections each includes
 a low pass filter connected in series with said anti-
 aliasing filter.

30 6. The apparatus of claim 4 wherein said fixed
 mass attached to each of said supplementary load
 cells is a weight which corresponds to the fixed mass
 attached to said corresponding one of said plurality
 of primary load cells.

5 7. The apparatus of claim 1 wherein said tire uniformity machine has a plurality of rotating components including said freely rotating load wheel, a motor driven spindle, and a plurality of motor driven rotating grinders.

10 8. The method of enhancing the measurement accuracy of a tire uniformity machine, comprising the steps of:

 monitoring forces generated by the vibration of said tire uniformity machine with primary load cells supporting a wheel spindle of said tire uniformity machine with a freely rotating load wheel mounted thereon and generating force measurement voltage signals in response thereto;

 monitoring forces generated by the vibration of said tire uniformity machine with a plurality of supplementary load cells mounted to said tire uniformity machine and generating differential voltage signals in response thereto;

 converting said force measurement voltage signals generated by said plurality of primary load cells into analog voltage measurement signals;

 reversing and converting said differential output voltage signals into analog differential signals;

30 summing said analog voltage measurement signals and said analog differential voltage signals and

5 outputting summed analog voltage signals equal to
their difference to said computer to substantially
cancel the effect of vibrational forces generated by
said tire uniformity machine.

10 9. The method of claim 8 including the step of
mounting said supplementary load cells in close
proximity to a corresponding one of said plurality of
primary load cells.

15 10. The method of claim 9 including the step of
attaching a fixed mass to each of said plurality of
supplementary load cells to simulate a fixed mass
attached to said corresponding one of said plurality
of primary load cells.

20 11. The method of claim 9 wherein said step of
converting said force measurement voltage signals
generated by said plurality of primary load cells
into analog voltage measurement signals includes the
step of amplifying said analog voltage measurement
signals.

25 12. The method of claim 11 wherein said step of
reversing and converting said differential output
voltage signals includes the step of amplifying said
analog differential voltage signals.

30 13. The method of claim 12 further including
the steps of:
converting said summed analog voltage signals to
digital signals;

5 converting said digital signals to a frequency domain representation;

 converting said frequency domain representation to a power spectrum representing the amplitudes of different frequencies; and comparing said amplitudes of different frequencies with acceptable amplitudes for selected groups of frequencies.

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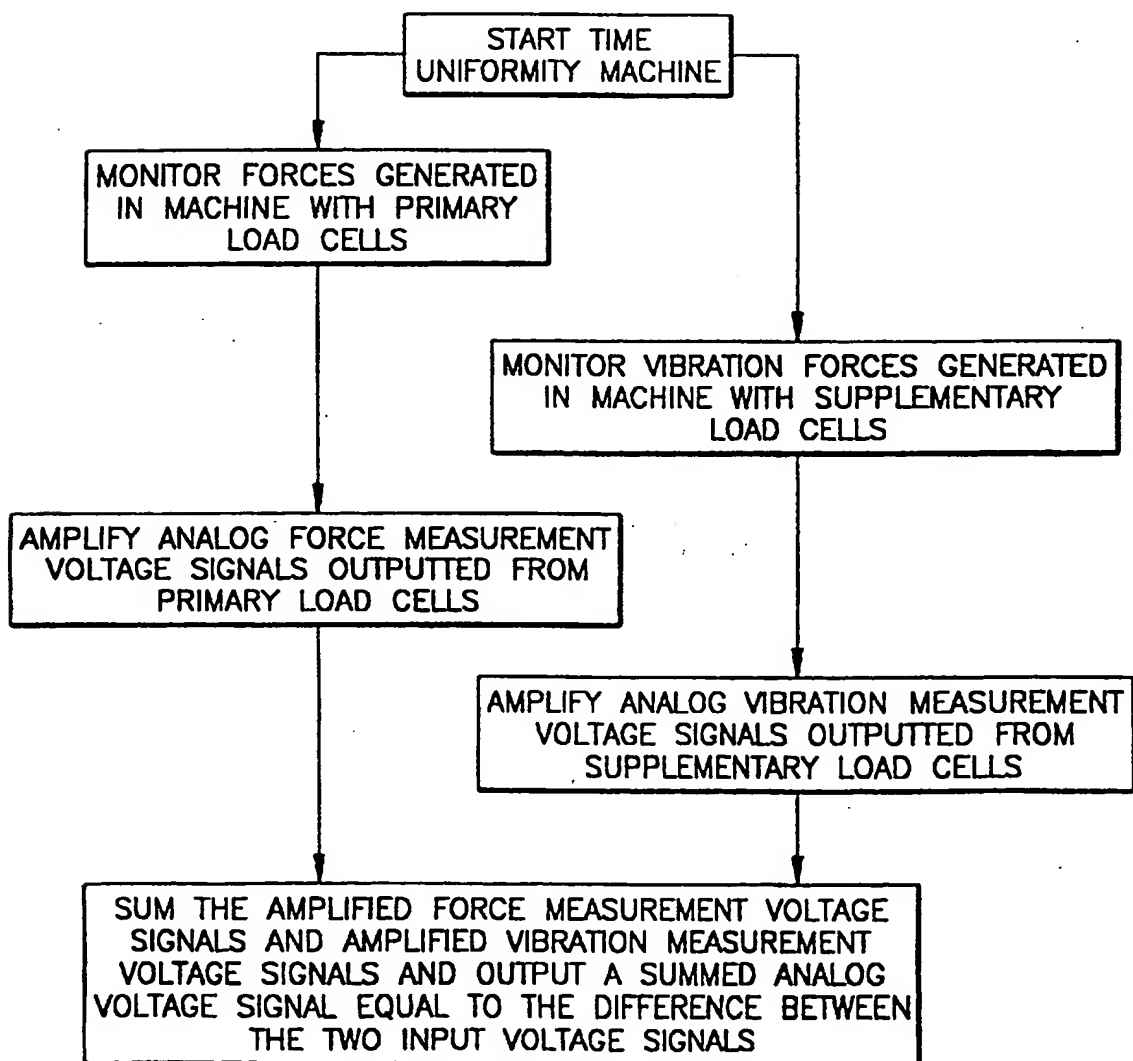
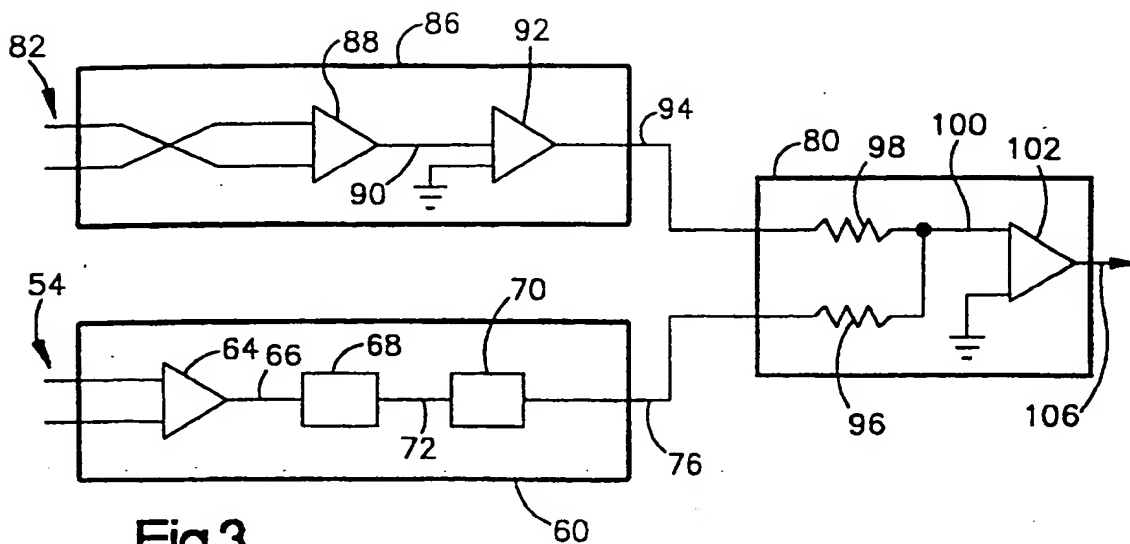
14. The method of claim 13 including the step of converting said digital signals to a frequency domain representation by mathematically operating on said digital signals with a Fast Fourier Transform equation.

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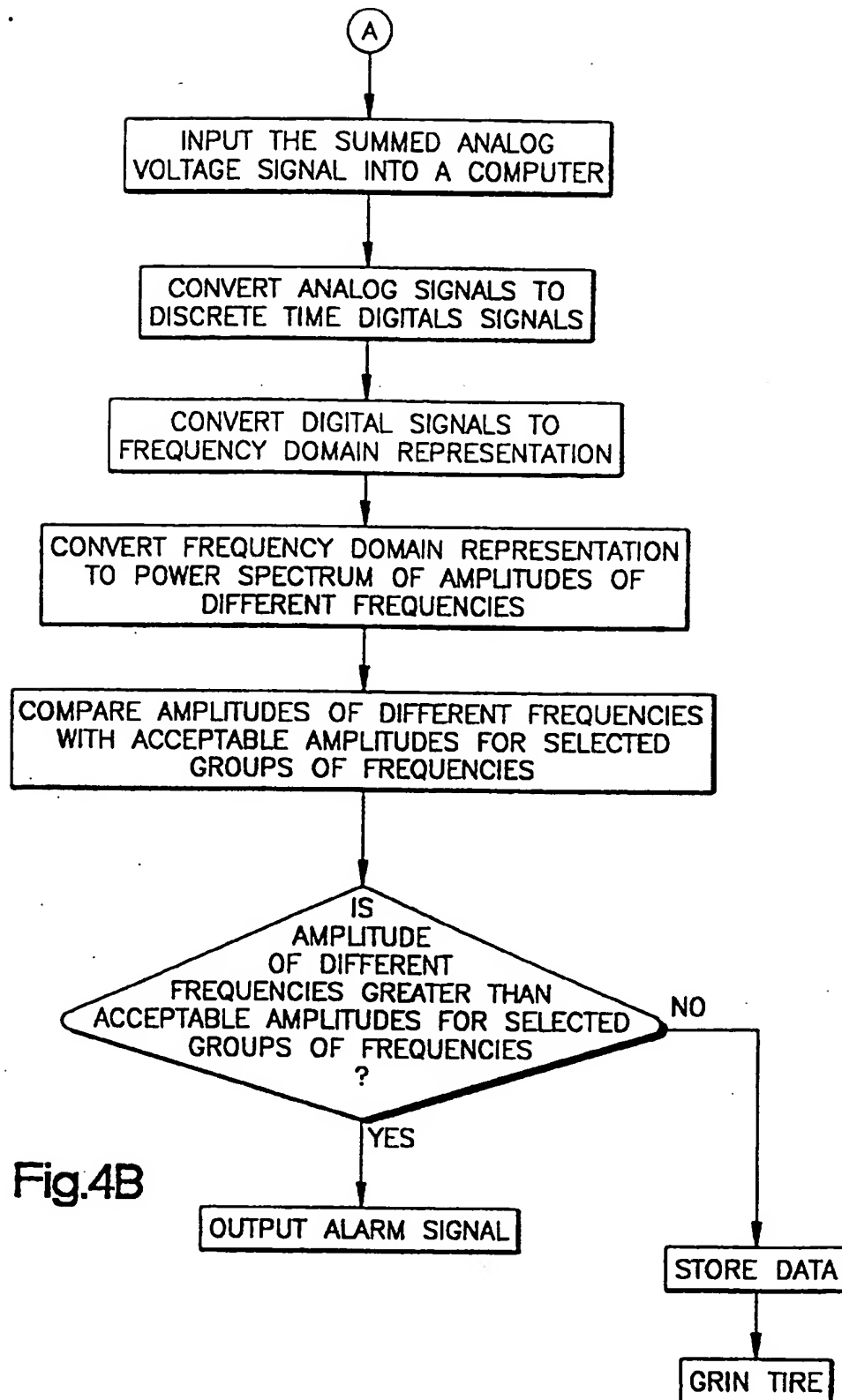
15. The method of claim 14 including the step of outputting an alarm signal from said computer when at least one of said amplitudes of different frequencies is greater than at least one of said acceptable amplitudes for selected groups of frequencies.

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 96/12484

A. CLASSIFICATION OF SUBJECT MATTER IPC 6 G01M17/02		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC 6 G01M		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 011, no. 068 (P-553), 28 February 1987 & JP 61 231432 A (YOKOHAMA RUBBER CO LTD:THE), 15 October 1986, see abstract	1,8
A	--- EP 0 342 773 A (GEN TIRE INC) 23 November 1989 cited in the application see abstract; figure 1 -----	1,8
<div style="display: flex; justify-content: space-between;"> <input type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex. </div>		
<div style="display: flex;"> <div style="flex: 1;"> <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="flex: 1;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div>		
Date of the actual completion of the international search <div style="text-align: center; font-size: 1.2em;">22 April 1997</div>		Date of mailing of the international search report <div style="text-align: center; font-size: 1.2em;">28. 04. 97</div>
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer <div style="text-align: center; font-size: 1.2em;">Zafiropoulos, N</div>

INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/US 96/12484

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		PT 90539 B	31-05-94
